Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/371
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

NUCLEAR POWER PLANT DYNAMIC STABILITY

P.A.Gavrilov, L.N.Podlazov.

Stability of nuclear power plants with a steam generator operating at a free level is considered when turbogenerator load and reactivity are changing.

A dynamic equation system is given and confirmed. Transfer functions for several parameters (in particular, power and pressure) are obtained in the form suitable for different modes of regulation including self-regulation.

It is shown that in most practically interesting cases transfer functions may be used as fractional rational functions with a characteristic equation of not higher than the fifth power.

A method of defining plant general parameters is presented ensuring a plant aperiodic stability with load and reactivity perturbations.

Nomograms are given to determine the plant dynamic characteristics (characteristic equation roots, decrements of attenuation, oscillation frequencies etc.). The nomograms may be directly used to select optimal characteristics and analyse dynamics of designed reactor and control systems.

As an example, the model developed is applied to the analysis of the АРБУС dynamics.

It is shown that the АРБУС dynamic parameters are in the vicinity of the aperiodic stability boundary when turbogenerator

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load is changing. Some recommendations are given aiming at improving dynamic characteristics of the plant.

The results of the АРБУС dymanics on an analog computer are compared with those on nomograms.

A choice of regulation model of the АРБУС is provided.

It is proved that there is no need for an automatic power regulator (AP) and that it is possible to operate nuclear power plants at a self-regulation régime.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/372
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

SPACE-TIME CORRELATION RELATIONS IN MULTIPLYING SYSTEMS

V.G. Zolotukhin and A.I. Mogilner

The paper includes some theoretical and experimental results of investigating space-time correlation functions of a reactor assembly. An interest toward such investigations is due on the one hand to the necessity to consider the character of the approximation of the already developed reactor noise theory which does not take into account the space localization of the detector. On the second hand theoretical investigation of neutron density as a random function of time and space co-ordinates permits one to introduce into the theory some reactor parameters which are not included in the elementary theory. Therefore it becomes possible to measure these parameters.

The paper defines a correlation function

$$M(\vec{r}_1,\vec{r}_2,t) = \langle m(\vec{r}_1,0)m(\vec{r}_2,t)\rangle - \langle m(\vec{r}_1,0)\rangle\langle m(\vec{r}_2,t)\rangle,$$

where $m(\vec{r},t)$ is the number of neutrons at time t inside volume v around point $\vec{r}$. By using a diffusion-age approximation specific results were obtained for homogeneous infinite multiplying subcritical media with isotropic scattering. Knowledge of the form of the correlation function permits one to determine all fundamental stochastic properties of multiplying and detection processes including spectral power density of the given correlation function, the autocorrelation function of detector counting rate, fluctuation of the number of neutrons in a reactor cell.

An experimental investigation was undertaken of the correlation between fluctuations of neutron flux detected by two ionization chambers inside a reactor. The chambers could be brought together or removed away from each other.

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Experimental results indicate that when the two detectors move away from each other the correlation between the fluctuation components of neutron flux, measured by the chambers, diminishes.

Comparison of experimental data and theory permits one to obtain information concerning space features of the reactor system (migration length, etc.).

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/373
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

CALCULATION OF THERMAL NEUTRONS UTILIZATION COEFFICIENT IN CELLS WITH COMPLEX FUEL ELEMENTS

G.A. Bat, E.A. Grigorjeva, V.N. Lebedev, et al.

Core lattices of many reactors contain instead of individual cylindrical fuel elements bunches of elements-channels surrounded by a layer of moderating material, which is longer than the free path of thermal neutrons. Thus ice-breaker "Lenin" reactors and physical and technical research reactor RFT have the canal structure. If the channel is split into a small number of cores it might lead to a considerable error in the calculations of thermal neutrons utilization coefficient. If one takes into account the channel structure and the change of its composition in the process of burning-out one has to use finite difference methods with several scores of nodes along the cell radius. Application of artificial methods, such as integral method of Amuajal and Benua is practically impossible. Solution of kinetic equation by expanding into spherical harmonics does not ensure the required accuracy if there is a thin absorber-type control rod (for example, a regulator) inside the channel. The Monte-Carlo method is probably possible only for the channels with low symmetry (such as first atomic power station channels). The methods of characteristics (Vladimirov) and of S_n (Carlson) seem to be more convenient for the symmetrical cells.

The computation time is greatly increased by combining the most precise possible account of thermalization and kinetic effects in one programme for the geometrically complex cells. It is rational to analyse the thermalization separately, in diffusion approximation and to use the obtained spectra for averaging cross-sections. Thus the problem is reduced to a solution of a single-velocity kinetic equation with cross-sections which are piece by piece continuous as function of co-ordinates.

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The paper gives a description of a diagram and of a programme of this type of calculations. The estimation of thermalization effects is based upon assumptions of Maxwellian (with variable temperature) nature of thermal neutron spectrum in the moderator and of absence of energy exchange between neutrons and fuel nuclei. The kinetic equation is solved by means of a somewhat modified method of characteristics. The number of characteristics may be less than that of the nodes along the radius. The data of P_1 or P_3 solutions are used as the first approximation. Iterations are done only externally, over the source. The diagram is approved of by comparing the results with the known data, including the experimental data for simple uranium-water lattices. In this case the coincidence turns out to be better than satisfactory.

In case of multi-layer cells the analyses of flux distribution and of thermal neutrons utilization coefficient values (obtained by P_1, P_3 and S_n methods as well) make it possible to arrive at a conclusion as to the necessary detailed structure of cell geometry and to the required accuracy of equation solution.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/374
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

MAXIMUM DENSITY OF NEUTRONS IN A REACTOR WITH LIMITED HEAT-UP OF THE COOLANT

Y.V.Shevelyov

Pulse-type homogeneous and heterogeneous reactors with one-way flow of the coolant have practically the same limit to which the neutron density can be increased. The maximum density is roughly equal to the energy which can be imparted to one volume unit of the coolant during one heating cycle divided by the energy liberated during one fission. If the design of the reactor is such that the coolant must be kept from plasma state, $n_{max.} \approx 10^{14}$ cm^{-3}. The limit can be extended by making use of the oncoming motion of the coolant streams.

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Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/375
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

EXPERIMENTAL STUDY OF SOME METHODS OF COMPENSATION OF HIGH EXCESS REACTIVITY

V.A. Kuznetsov, L.A. Tshernov and V.I. Sharadin

The paper contains results of experimental investigations of the methods of compensation of high excess reactivity by separating two halves of the core or by inserting compensating cylinders enclosed in boron-containing material into a side beryllium reflector.

The efficiency of these methods of compensation is compared with that of a single boron-carbide rod placed in the centre of the core.

The distortion of the neutron density distribution is presented as a function of the angular position of the recompensation cylinder and of the separation between two halves of the core.

An attempt was made to evaluate the efficiency of separating halves of the core for intermediate reactors by numerical computations based on one-group theory.

The results of the investigation of the absorbing rods interference prove that the main contribution to the interference comes from pair interactions.

The experimental data permit to evaluate the efficiency of the absorbing rod system.

The experiments were carried out with beryllium moderated intermediate zero power reactors on the PF-4 physical assembly described elsewhere.

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Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/376
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

COMPENSATION OF LARGE CHANGES IN THE REACTIVITY BY DEFORMATION OF THE CORE LATTICE

G.A.Bat, G.V.Mukhina, D.M.Parfanovich et al.

Prolongation of the power reactor life entails the increase in the reactivity margin of the newly loaded reactor and, therefore, calls for the development of an effective system compensating for this margin. Along with the conventional systems such as the shim rods and assemblies, burnable poisons, mixtures of heavy and light water, it is deemed advisable to discuss the possibility of controlling the reactivity by means of a relatively slow deformation (variation of the effective spacing) of the core lattice in the moderator. This is most feasible in the case of liquid-moderated reactors with channel type cores (the type of the core employed in the reactors of the icebreaker LENIN). Deformation of the lattice is, in a sense, similar to controlling the reactivity by changing the concentration of the heavy and light water mixture, in that its effect does not cause considerable distortions of the energy release field corresponding to the insertion of the permissible number of the absorbing rods. However the flexibility of the suggested method is rather high. The difficulties involved in the development of such control systems are due to the necessity to have a considerable number of kinematic pairs in inaccessible points of the reactor, to arrange "light" but quick-acting control and safety components in the movable lattice and to adapt the system to operation at a varying temperature effect.

The work on the development of the new control system was

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carried out along three main lines: critical experiments, mathematical description (including calculation codes for high-speed computers), designing of the core.

Several series of critical experiments confirmed the effectiveness of this method of control and made it possible to find out its physical pecularities and work out simple but sufficiently accurate computer codes. The experiments were carried out with individual fuel elements and with bundles - channels.

The paper describes several design schemes of cores with deformable lattice.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/377
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

PHYSICS OF REACTOR SHIELDING

O.I.Leipunsky et al.

The rapid progress in the utilization of nuclear energy gave rise to a science of nuclear radiation shielding one of the branches of which is the physics of shielding. The physics of shielding covers the investigations of radiation fields, migration of radioisotopes, physical standartization of the biological effects of radiation.

The knowledge of radiation fields in the matter is of special importance.

The development of the research techniques requires new experimental facilities and new theoretical approaches. The paper mentions new equipment for carrying out research in the field of shielding.

Many problems connected with the gamma-ray and neutron fields have been solved in the recent years. A prominent place is held in these investigations by a method whereby the field of an elementary radiation source is investigated first and then the field of a real source is treated as a superposition of the fields from the elementary sources. For a long time an elementary source was taken to be a point isotropic source.

However, a point monodirectional source (narrow ray) is a more elementary source which can be used to form all sources treated before (isotropic point, isotropic plane and anisotropic sources). The paper presents the results of the experimental study of the fields from monodirectional point sources in various media and the empiric formulae which describe the results of the experiments. A useful contribution to the calculation of the field of a monodirectional point source can be made by the use of adjoint functions for solving the kinetic equation of the transfer of γ -quanta.

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Calculation of the shielding is connected with the evaluation of the biological effect of penetrating radiation. Hence the necessity for more accuracy in determining the spectrum of neutrons coming through the shelding and for evaluation of the radiation dose from intermediate-energy neutrons. A "dose storage factor" was introduced to describe the doses. This "dose storage factor" was calculated for various compositions and various arrangement of the reactor shielding layers.

An extensive use of reactors poses an important problem of shield optimalization. The convenient methods for solving this problem are still being sought for. One of such methods is the introduction of the function "effectiveness of the shielding material versus specific process". The mathematical methods of treating this function, particularly, the methods of the perturbation theory make it possible to find the conditions for the optimal composition of the shielding.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/378
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

SAFETY PROBLEMS OF ATOMIC SHIPS

B.G.Pologikh et al.

The paper presents the calculations and theoretical conclusions which indicate that the basic recommendations with respect to atomic-powered ships contained in the International Convention for the Safety of Life at Sea 1960 can be successfully complied on the icebreaker LENIN. Specific data obtained in the course of the practical operation of the atomic plant of the icebreaker are shown. They confirm the practicability of the theoretical calculations.

The paper discusses the possible radiation hazards resulting from the collision of an atomic-powered ship with other ships. It presents the calculations of the possible outlet of radioactive fission products from the primary circuit in the case of moderate leakages or in the case of such situations as bursting of the pipe line in the primary circuit, when the reactor core will be left without water. Evaluation is made of the amount of core destruction that can be caused by the afterheat release in the uranium.

Translation provided by courtesy of the submitting Government

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/379
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

SOLUTION OF THE PROBLEM OF SANITARY PROTECTION OF THE ENVIRONMENT FROM RADIOACTIVE CONTAMINATION IN THE SOVIET UNION

F.G.Krotkov, A.N.Marei et al.

The problem of sanitary protection of reserviors, underground waters and the atmosphere and soil from contamination with radioactive waste has assumed in the Soviet Union a tremendous nationwide importance. It is aimed at ensuring radiation safety to the population.

The sanitary requirements presented to the distribution of enterprises for the extraction, processing and use of nuclear fuel, the conditions for the discharge of radioactive waste into the atmosphere and the permissible doses of radioactive substances in the air, reservoirs and subterranean sources of water supply are governed by unified sanitary regulations published by the sanitary inspection bodies of the Ministry of Health Protection which have the force of law.

The principle underlying this problem is to prevent the contamination of the environment with radioactive substances and to keep the population out of contact with them. This is achieved by employing a differentiated approach to the utilisation of various methods depending on the type of enterprise and the nature of radioactive waste. Among the principal ones are an all-round reduction in the amount of liquid and gaseous wastes to be removed, their localisation at the place of production, measures for their effective dispersement and deconcentration and the arrangement of sanitary protection belts which isolate the population from them.

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Adequate sanitary conditions have been created by means of these methods (changed production processes, closed circulation cycles for liquid waste, decontamination at uranium mines, plants for processing uranium ore, etc).

The problem of sanitary protection of the environment in the vicinity of operating atomic reactors and atomic electric power plants is also being successfully solved along various lines.

Reliable burial of waste is of especial interest from the viewpoint of hygiene. Although these measures involve a certain capital outlay they give a good sanitary effect which is of decisive importance in this problem.

As a result, a contamination hazard has been considerably reduced as regards subterranean water supply sources and reservoirs and the atmospheric air near the ground.

The tasks that face specialists in this sphere are to improve still more the methods called upon to ensure radiation safety for the population.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/380
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

GUIDE PROVIDING NUCLEAR SAFETY OF POWER REACTOR IN THE USSR

G.A.Gladkov, B.A.Buynizky, Yu.G.Nikolaev et al

At present a guide providing nuclear safety of power reactors has been developed in the USSR. The guide is obligatory for all researc and designing organizations. The guide comprises a code of requirements to the reactors and auxiliary systems, designed to exclude the possibility of uncontrolled power growth. The primary attention is devoted to the automatic control and emergency shielding systems.

The guide regulates the measures providing the impossibility of fast reactivity introduction compared to the portion of delayed neutrons during all unstable processes: power variation, heat-up and cooling after emergency shielding action . The guide introduces the requirements contributing to emergency shielding reliability. The conditions which the core construction must satisfy are established from the point of nuclear safety.

The paper contains the discussion on the operative rules.

Translation provided by courtesy of the submitting Government

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/381
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

CRITICAL PARAMETERS OF URANIUM SALT AQUEOUS SOLUTIONS AND NUCLEAR SAFETY

B.G.Dubovskii, A.V.Kamaev, G.M.Vladykov et al

Experimental and theoretical investigations on critical parameters of uranium salt aqueous solutions with 90,10 or 5 per cent enrichment are described. There investigations were carried out for determination of nuclear safety conditions and for studies of homogeneous reactor physics. Critical volumes of the solutions defermined at various uranium concentrations in the range of 30-450 g/l.

Extrapolation lenghths and effective additions of various reflectors were determined during experiments.

The experimental results obtained for cylinder and rectangular cores by transformation of geometrical parameter using the extrapolation lenghth and effective addition of light water reflector, were recalculated for cores having shapes of a sphere, infinite cylinder and infinite flat layer.

These values were compared with the results of experiments, conducted on cores having the shape of a sphere and infinite cylinder.

The report includes the results of experiments for determination of critical size dependence on per cent content of steel and nitric acid in the core, as well as the results of experiments for defermination the effect of various compound reflectors on critical parameters.

The theoretical analysis of experimental data was carried out in two ways: by solution of multigroup equations for a reactor in P_1 and P_3- approximations and by empirical nuclei method. An idealized problem on water moderated reactor was solved for testing

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the validity of various approximations. The calculation method and the cross-sections used are shown to give the results which are in good agreement with experiments.

On the basis of this analysis the material buckling and extrapolation boundary of water moderated reactors are derived.

The report includes the results of experiments on determination of effectiveness of absorbing rods of different shapes and composition in homogeneous uranium-water reactors with uranyl nitrate solutions.

The effectiveness of regular absorbing rod lattices with various pitches and uranium concentration in the solution was also determined.

Multigroup calculations on determination of effectiveness of the central cylindrical rod of boron carbide with steel canning are reported.

The calculation method presented in the report for determination of effectiveness of regular absorbing rod lattice in the reactor consists of homogenization of the core with absorbing rods.

The effectiveness and the homogenization parameters of the infinite absorbing rod lattices in homogeneous multiplying media are determined with the account of the detail energy dependence on absorption and scattering cross-sections of rod material.

The effectiveness and cross-sections of infinite lattice rods are derived in a diffision age approximation on the basis of the analysis of an equivalent cell in the one-dimensional geometry.

The results of the calculation of the effective absorption cross-sections of the absorbing rod in a cell were used for a multigroup calculation of reactors with rod lattices.

Results of experimental investigation and calculations on neutron interaction of subcritical assemblies with aqueous uranyl nitrate solutions are described.

A certain number of experiments were made with 2,3,4 and 5

cylinders (d = 30 cm) and parallepipeds placed on the same plane but at different spaces.

The results of the experiments with 6-liters wessels placed in a flat and spatial lattices on different spaces are also described.

The authors describe the calculation method of interaction of fissible systems based on determination of "effective" sizes for such cylinders which make up the whole system.

The results of the experiments are compared with those of calculations performed by the "effective size" method.

The review and comparision of some existing methods of interaction calculation are given.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/382
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

DYNAMICS OF WATER-MODERATED WATER-COOLED REACTORS AT ACCIDENTAL DROP OF COOLANT CIRCULATION

G.N. Poletayev

The first part of the work contains a system of equations to be employed for computing the change of the coolant circulation in the primary circuit of the multipool water-moderated water-cooled reactor when the operating conditions of the circulating pumps are changed or disturbed. Conditions of system consistency are cited. Analytic solutions of some cases are given.

A detailed analysis of the circulating pump deenergizing or breaking is made. Typical time constants for drop of circulation are obtained and analyzed for different reactors employing various types of circulating pumps.

The analytic solutions are compared to the computer calculations and experimental data. Performance of a bench test for determining the drop of coolant circulation is highly recommended.

In the second part of the work an analysis is made of the heating conditions in the water-moderated water-cooled reactor in case of pump deenergizing. The reactors with various types of fuel elements are considered. Criteria are obtained which will allow the operators to keep the heating conditions in the reactor within the specified limits (for instance, lack of coolant bulk boiling and heat exchange crisis or maximum tolerable temperature of the fuel element in case of heat exchange crisis). Some calculated data are cited which are compared to the available experimental data.

Translation provided by courtesy of the submitting Government

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/383
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

USE OF ISOTOPES FOR QUANTITATIVE INVESTIGATION OF ATMOSPHERE MOVEMENT

I.L.Carrol, S.G.Malakhov, I.K.Kikoin et al

The study of distribution of radioactive substance in the lower air layers of the earth atmosphere conducted in various geographic points has given important information on some large-scale processes taking place in the atmosphere.

Materials of 11 ocean expeditions collected between 1958 and 1963 and continental data made it possible to study:

1. general meridional circulation of atmosphere;
2. intercommunication between concentration of radioactive substances and atmospheric pressure;
3. air masses exchange between hemispheres;
4. certain characteristics of the air masses exchange between troposphere and stratosphere;
5. influence of ocean and land surfaces upon air masses exchanges between the troposphere and stratosphere;
6. the role of metereological fronts, as the demarcation line of various air masses.

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Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/384
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

CONTAMINATION OF OCEANS BY LONG-LIVED ISOTOPES ACCORDING TO DATA OBTAINED BY SOVIET INVESTIGATIONS

V.M. Vdovenko, L.I. Gedeonov,
L.M. Ivanova, et al

The report contains a review of data on the contents of strontium - 90 in the waters of the Pacific, Atlantic and Indian oceans and Cezium - 137 in the waters of the Atlantic ocean obtained by Soviet scientists in the period 1959-1963. A short review of the methods used, and the results of the analyses of over 250 samples of ocean water taken from the surface and deep horizons are given.

The results of the analyses of the samples permit to draw the conclusions on the specific features of the process of radioactive contamination in each of the oceans. The contamination of the Pacific is caused by local ingression of a considerable portion of the fission products of nuclear explosions, conducted by the USA and Great Britain, and the global-scale process of radioactive fall-out. The currents existing in the Pacific have created a severe contamination of the north - western area of the Pacific ocean and therefore the USSR and Japan pay special attention to investigations carried out in this area.

The investigations carried out in the central area of the Pacific ocean during the period when there was a "lull" in nuclear testing show that the globular fall-out acts here along with dispersion of the local repository from the zones of the test sites.

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The investigations carried out in this area may give especially valuable information for solving the problem of subaqueous burial of radioactive wastes in the ocean.

The nature of the contamination of the Indian, and expecially the Atlantic oceans by strontium - 90 differs from the picture visualized in the Pacific ocean. The main source of this isotope here is the global radioactive fall-out. Based on data obtained from a series of cruises, a number of interdependencies are coming to light characterizing the distribution of strontium - 90 in the surface waters.

The dependency of the strontium - 90 concentration on the latitude and on oceanic currents is noted in particular, and a hypothesis is suggested in that the contents of strontium-90 in the surface layer of the ocean indicate not the total deposits, but the rate of fall-out of this radioactive nuclide.

Several depth cross-sections have been plotted, showing the contents of strontium - 90 in the various horizons. The analysis of the data obtained allows to strengthen the arguments in favour of the assumption that for the penetration of strontium - 90 into the depths is responsible not only the turbulent diffusion, but also the transfer of water masses in the process of circulation.

Based on results obtained, an estimation was made of the amount of strontium - 90 stored in some ocean areas. This estimation shows that the deposits per unit surface of ocean exceeds the quantity of strontium - 90 that has fallen out along the same latitudes per unit of surface of the dry land. This summary indicates the necessity of studying the specific features in the process of fall-out of radioactive products on sea surfaces compared with the processes, that regulate the fall-out on the dry-land surface.

The report contains the first Soviet data on contents of cesium - 137 in ocean waters.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/385
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

SOME REGULARITIES OF THE DISTRIBUTION AND MIGRATION OF RADIOACTIVE ELEMENTS IN THE SOIL STRATUM

V.I. Baranov, F.I. Pavlotzkaya,
E.B. Tyurukanova, et al

The study of the contents and distribution of natural radio-isotopes and their radioactive decay products with different chemical properties created in soils, and the infiltration into the soil of artificial radio-isotopes (strontium - 90, cezium - 137, etc.) with atmospheric precipitation, due to nuclear testing and peaceful uses of atomic energy, in conditions of natural stratification of soil, is of great scientific and practical interest.

A large amount of factual material on the contents of natural and artificial radioisotopes in the upper layer of the soil covering has been already accumulated. There have been no investigations insofar, on distribution of them among the genetic horizons of soils in various landforms and only a few amount of data on radiometric determinations of natural radioelements and penetration of large quantities of artificial radioactive isotopes into the soil was available.

The aim of this work is the study of the contents and distribution of natural radioelements and radioactive strontium in various types of soil in conjugate landforms, which play a considerable role in the distribution of chemical elements over the terrestrial surface.

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The following results hage been obtained in the course of research carried out:

1. The content of natural radioelements in soils of the USSR (excluding abnormal areas) varies from 4.10^{-6} to 16.10^{-4} per cent for thorium , from 1.10^{-12} to $1.7 \cdot 10^{-10}$ per cent, for radium from 3.10^{-6} up to 5.10^{-4} per cent for uranium.

The variation of contents in the seat, soil-forming,and ledge rocks does not exceed one order of the value.

In the soils investigated, the relation Th: U is 0.3 to 4.8.

2. The highest level of radioactivity is found in soddy-- bog, alluvial clay-bearing soils of river bottom-lands (Th= 15.10^{-4} per cent; U = $4.8.10^{-4}$ per cent), the minimum level is found in sandy soils particularly in peat upland bogs (Th= (4 to 8) . 10^{-6} per cent;U=(2.4 to 6.6).10^{-6} per cent).

3. The differentiation of radio-elements in some types of soils (chernozem, grey forest, some of the soddy-podzolic soils) over the profile is not considerable.

Accumulation of radio-elements, is observed, as a rule, in alluvial, gleisol and sometimes in carbonate horizons of various types of soils.

4. Distribution of radio-active elements which have entered from the atmosphere in the soil stratum, depends considerably on locality conditions.

5. Radiostrontium accumulates mainly in soils in areas located near bottom lands and boggy depressions. The degree of accumulation depends on the specific features of the bottom lands.

6. The vertical distribution of strontium - 90 depends on the type of soil, the structure and composition of the surface horizon and on some other factors.

Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/386
USSR
February 1964
Original: RUSSIAN

Confidential until official release during Conference

Abstract

GENETIC EFFECT OF SMALL DOSES OF IONISING RADIATION

N.P.Dubinin, M.A.Arsenieva,
Y.L.Glembotsky et al.

The introduction of atomic power engineering into industry and the radiation sources into medicine and agriculture and the continuing fallout of radiactive aerosols after the test atomic bursts require an appraisal of the genetic effects of small doses of ionising radiation.

The investigations carried out on Drosophila with the use of gamma rays from Co-60 and 130 Mev protons at a level of 5 rads as well as of a fast neutron flux of the reactor at a level of 2 rads showed the absence of threshold upon provoking flying mutations and the presence of a cumulative effect. Continuous irradiation of Drosophila, while in the state of larva and chrysalis, as well as at the imago stage with gamma rays for 12-14 days at a radiation intensity of 8 r per day produced in terms of 1 rad the same mutagen effect as an acute irradiaion with gamma rays in a dose of 1,000 r. These data show that there is no dose thre shold for genetic effect; impairement of heredity can be caused by any small doses in quantities corresponding to the dose value.

The effect of gamma rays in doses of 10,25,50 and 100 r was investigated in meiosis in monkeys and mice in average pachynema, diplonema, in diakinesis and metaphase. On an average, in the meiosis prophase there appear, per 1r, 0.15% chromosome transformations in monkeys and 0.06% in mice. A tendency has been detected to a higher injury per 1 r when acting with a dose of 10 r as compared with the effect produced by 25,50 and 100 r.

Investigations carried out on human cells in a tissue

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culture showed a level of cytogenetic effectiveness of gamma rays from Co-60 in doses of 10,15,25,35,50 and 100 r. Analysis of chromosome and chromatid transformations was carried out with account taken of the course of separate phases and the total duration of the cell cycle under the action of different radiation doses. It is shown that doses of 10 and 15 r in no way prolong the cell cycle. Doses of 25,35 and 50 and 100 r retard the cycle which lasts for 70 and more hours instead of 18-20 hours registered in control. A dose of 10 r for a number of separate phases of the nucleus cycle has been found to double the quantity of the natural nucleus transformations.

Cesium-137, strontium-90 and carbon-14 are the main radionuclides upon the fallout of aerosols following atomic explosions. It has been believed for a long time that Sr-90 has no genetic effects. This idea has been reconsidered now. In model experiments on unicellular organisms we have obtained proof of a mutagen effect produced by Sr-90. The experiments conducted on Drosophila have shown that the incorporated radionucloid of C-14 possesses a clearly delineated mutagen effect. Continuous irradiation in the stage of larva and chrysalis with beta rays of incorporated C-14 produces a mutagen effect close to the one observed in continuous irradiation with gamma rays both in the state of larva and chrysalis and at the imago stage.

The protection of the cell nucleus structures from the damaging action of radiation is the most important element in the problem of the effect of small doses of radiation on heredity. Experiments conducted on the chemical protection of chromosomes in human cell nuclei have shown that the protection at the level of small doses proceeds in another form as compared with the protection when large radiation doses act on the nucleus. This discovery presents in an entirely new light the problem of protecting heredity in the presence of small doses.

In conclusion, the paper gives a tentative quantitative estimation of the effect produced by small radiation doses on human heredity with account taken of the relative biological effectiveness of various types of radiation.